AFRL-VS-TR-2002-1641

DEVELOPMENT AND VALIDATION OF A GLOBAL DYNAMO MODEL AND ITS COUPLING TO THE CITFM

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May 2000

Final Report

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REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
15 May 2000

3. REPORT TYPE AND DATES COVERED
FINAL REPORT (SUMMARY)

4. TITLE AND SUBTITLE
Development and Validation of a Global Dynamo Model and Its Coupling to the CITFM

5. FUNDING NUMBERS
PE: 63707F
PR: 2688
TA: SS
WU: BB

Contract No. F19628-98-C-0020

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory
29 Randolph Road
Hanscom AFB MA 01731-3010

Contract Manager: W. Borer/VSBXP

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AFRL-VS-TR-2002-1641

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This is a summary of the work accomplished under this effort. Develop and validate a global dynamo model and couple it to the Coupled Ionosphere and Thermosphere Forecast Models (CITFM).

14. SUBJECT TERMS
Global dynamo model
Ionosphere
Thermosphere forecast models

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

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15 May 2000

Dr. William Borer
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Re: Contract F19628-98-C-0020
"Development and Validation of a Global Dynamo Model
and Its Coupling to the CITFM"

Dear Bill:

On March 9, 2000 the above referenced contract was descoped and a revised "Statement of Work (SOW)," "Deliverables," and "Cost Proposal" were negotiated. The changes are documented in the attachments to this letter. One of the changes involved the Final Technical Report, which was to be replaced with a letter (approximately 2 pages) detailing the relationship of the accomplished tasks to the overall effort, as originally scoped. This letter constitutes the Final Technical Report for the above referenced contract.

The original proposal, dated 1 May 1997, consisted of the following six tasks:

Task 1, Develop a global dynamo electric field model.

Task 2, Help PL scientists with the validation of the coupled ionosphere and thermosphere forecast models (CITFM).

Task 3, Develop a procedure for forecasting magnetospheric convection and precipitation patterns.

Task 4, Construct a T_e and T_i solver for the low-latitude region of the ionosphere.

Task 5, Help PL scientists couple the global dynamo and CITFM models.

Task 6, Help with the validation of the coupled dynamo-CITFM system.

Tasks 1 and 5 have been completed, which involved the global dynamo model. The dynamo model was needed in order to calculate self-consistent electric fields produced by the

action of the global neutral wind. These self-consistent electric fields are particularly important in the equatorial region because they are associated with spread F and plasma bubbles. However, in order to get an improved conductivity distribution for the dynamo model, it was decided to transform the IFM to a geographic output instead of a geomagnetic output, and then to incorporate the IGRF magnetic field definition into the low-latitude portion of the IFM. It was also decided to improve both the latitude and longitude resolutions of the IFM. These changes were made and the modified code (IFM Version 4.0) and updated manual were delivered to AFRL.

After the modified IFM was delivered to AFRL, PL scientists noticed that some peculiar ionospheric features could appear at certain places and at certain times. These problems were traced to the following four causes: (1) The HWM developed by Hedin had to be modified in the high-latitude region in order to obtain reasonable ionospheric densities, but the same modifications were not made at low altitudes; (2) At mid-latitudes, the IGRF field had to be blended to the dipole field used in the high-latitude part of IFM and the blending was not entirely smooth; (3) The IGRF dip and declination angles were not being used to calculate the field-aligned component of the neutral wind in the low-latitude code even though the IGRF was used to trace the location of the $\underline{B}$ field lines in geographic coordinates; and (4) At times, the top boundary condition for the density solver was not correct due to a round-off error on the computer, which would lead to erroneously high electron densities during high magnetic activity. These problems were worked on and corrected during the time period from February to April 2000, and then a new version of the IFM was delivered to AFRL.

With regard to Tasks 2, 3, 4, and 6, only Task 4 was worked on, but the work was not completed. At the beginning of the contract work, it was decided not to pursue the development of the T_e and T_i solver for the low-latitude part of the IFM, but instead to conduct a sensitivity study of the low-latitude electron density to both T_e and T_i. This work was initiated but not completed.

Sincerely,

R.W. Schunk

Robert W. Schunk
Principal Investigator & President